



BESSEMER STEEL,

EXHIBITED BY

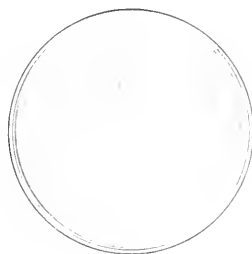
FAGERSTA BRUK

AT THE

INTERNATIONAL EXHIBITION IN PHILADELPHIA.

1876.

CHR. ASPELIN,
MANAGING DIRECTOR,
WESTANFORS, FAGERSTA,
SWEDEN.





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2491
J. B. Lippincott & Co.
Philadelphia

FAGERSTA STEEL WORKS.



PRODUCTS EXHIBITED.

1. **Iron Ores**, from the mines of Granroten, Gröndal, and Stortäkten.

Roasted **Iron Ores**.

Limestone.

Pig Iron and **Blast-Furnace-slag**.

(For analyses see Annex No. I.)

2. Series of broken 9-inch **Bessemer Steel Ingots** of various degrees of hardness, with **Blooms** forged from pieces of the same. **Slag** from the converter.

3. Column, containing: **Bessemer Steel**, for machinery, square and round, from $\frac{5}{8}$ to 5 inches diameter.

ANALYSES AND CERTIFICATES.

ANNEX I.

The Iron Ores and Limestone, employed at the Charcoal Blast Furnaces at Westanfors and Fagersta, consist of the following component parts:

	IRON ORE FROM THE MINES OF:			
	"Östra Stortäkten."	"Granroten."	"Gröndal."	Limestone from "Hedkärna."
Silica.....	27.49	3.10	6.35	10.82
Alumina.....	1.30	2.05	1.15	7.15
Lime.....	2.16	1.20	2.65	36.61
Magnesia.....	1.76	1.05	3.85	6.86
Protoxide of Manganese.	0.81	10.40	5.50	1.25
" " Iron.....	20.74	23.56	22.82
Sesquioxide of Iron.....	46.14	52.44	50.78
Carbonic Acid.....	6.10	5.95	37.18
Phosphoric Acid.....	0.016	0.009	0.014	0.007
	100.416	99.909	99.064	99.877

The Average Chemical Composition formed by the mixture of these Iron Ores with the Limestone, employed as flux, is as follows:

	Per ct.	Oxygen.	Oxygen.
Silica.....	11.93	6.37	
Alumina.....	2.50	1.10	
Lime.....	7.51	7.53	2.14
Magnesia.....	2.76	1.10	7.53 = 1.66
Protoxide of Manganese.....	5.63	1.27	4.51
" " Iron.....	19.76	4.51	
Sesquioxide of Iron.....	43.89		
Carbonic Acid.....	6.02		
Phosphoric Acid.....	0.013		

Such a charge yields, upon smelting, from 48 to 50 per cent. of Pig Iron, which is tapped direct from the blast furnace into the

ANNEX I.—*Continued.*

**Tramway-rails and
Angle-Steel.
Steel for Springs,**
from 1½ to 4 inches.

Bessemer Converters, and consists on the average of the following component parts:

	Per ct.
Carbon, combined.....	3.460
“ graphitic.....	1.289
Silicon.....	0.771
Manganese.....	4.491
Phosphorus.....	0.027
Sulphur.....	trace.

The Blast Furnace slag contains:

	Per ct.	Oxygen.	Oxygen	
Silica.....	41.96	22.83		
Alumina.....	7.02	3.27		
Lime.....	25.04	25.65	7.16	
Magnesia.....	17.75	7.09	25.65	1.62
Protoxide of Manganese.....	6.57	1.48	15.78	
“ “ Iron.....	0.23	0.05		
Alkalies.....not determined.		15.78		
	98.57			

As no Spiegeleisen or ordinary Cast Iron is employed, the “blow” must be stopped when the proportion of carbon in the steel is reduced to the proper degree. Notwithstanding this, the steel is entirely free from red-shortness.

The following analyses show the chemical compositions of the various classes of steel employed for the purposes specified:

	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
	Per ct.	Per ct.	Per ct.	Per ct.	
a) Steel for Soft Plates, Railway Axles, etc....	0.085	0.008	Trace.	0.025	Trace.
b) Steel for Gun-Barrels, Shafts, etc.....	0.25	0.036	0.234	0.022	“
c) Soft Steel for Tools; Saws, etc.....	0.70	0.032	0.256	0.023	“
d) Hard Steel for Tools; Chisels, Turning Tools, etc.....	1.05	0.007	0.355	0.028	“

An Analysis of the Slag from the converter, taken at the close of the process, shows its composition to be as follows:

Silica.....	46.70
Alumina.....	4.24
Lime.....	0.48
Magnesia.....	0.17
Protoxide of Manganese.....	32.37
“ “ Iron.....	15.63
	99.59

E. BRUCEWILL.

4. For Engineering Works:

Crank-Shafts, Locomotive Cranks.

Various Forgings for Machinery.

(See Annex No. 2.)

5. Spikes and Nails.

a. **Forged Spikes, Nails, and Nailrods.**

b. **Cut Nails and Flat Iron for Cut Nails.**

6. **Railway Apparatus:**

Axles, among which is one tested by several strokes from a ram of 12 cwt.

Springs.

Buffers.

(See Annex No. 3.)

ANNEX II.

Upon request, we hereby certify that during the last years we have always used to the more important movable parts for steam-engines made by us, such as connecting-rods, cross-heads, crank-shafts, propeller-shafts, and shaftings in general, steel from the Fagersta Steel Works, and found the same to be of excellent quality, tough, dense, and homogeneous, and consequently forming very superior wearing-surfaces in bearings, etc.; so much so that it has never occurred that any shaft or part of engine made from aforesaid steel has sprung, or in any case proved defective in spite of very severe trials.

Göteborgs Mekan. Verkstad, the 22 Febr., 1876.

Göteborgs Mekaniska Verkstads Aktie-Bolag.

JAMES KEILLER.

The undersigned has for a long time been using Bessemer steel of various temper, from the Fagersta Iron and Steel Works, for all machinery purposes, and on request of my opinion, I hereby certify that this steel is of an excellent quality, and has all the good properties of strength and elasticity that may possibly be demanded, and I consider it fully comparable with English crucible cast-steel in regard to its homogeneity.

The Engineering Works of Eskilstuna, March 4, 1876.

THEOFR. MUNKTELL,

Machinery Manufacturer.

At the request of Mr. Chr. Aspelin, I hereby mention that, during many years, Fagersta Bessemer steel is used in our Engineering Works for railway-axles and shafts, and also for all kinds of forgings for machinery; and I hereby certify that this steel has proved to be very suitable to the said purposes, and is of the best quality.

Arboga Engineering Works, March 11, 1876.

C. I. OLSSON.

ANNEX III.

Hereby is certified at the request of the *Fagersta Steel Works*, that in order to ascertain the quality of Bessemer Steel Axles, manufactured at the said Works, this axle was without previous choice taken out from a lot of two hundred axles, ordered for the Swedish State Railways, and tested in the following manner and with the following results:

The bearings of the axle were turned in sharp corners nearest to the shaft, the axle was then laid on two sharp edges, one under the middle of each bearing, and received blows in the midth of the shaft with a ram of 12 cwt. weight, from a height of successively 5 feet to 20 feet. When showing the inflexion of about 10 inches, the axle was turned around and again straightened by several blows with the same ram from a height of 24 feet.

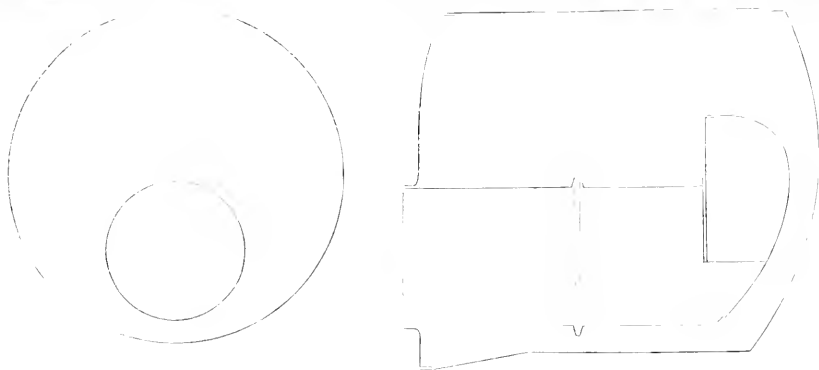
Stockholm, February 22, 1876.

C. O. TROILIUS,

General Director.

FRED. ALMGREN,

Chief Director of Rolling Stock.



ANNEX IV.

7. **Saw Blades.**8. **Plates.**

Slabs, hammered,
broken for showing
the fracture.

Slabs, rolled.

Steam Boiler, made
from Fagersta steel,
and showing its tough-
ness.

(See Annex No. 4.)

At the Göteborg Engineering Works in the course of the summer 1869, a small Steamer was supplied with a 10-horse power high-pressure Engine and a Boiler, constructed as shown above. After a year the Steamer returned to the said Works for repair of the Boiler. By shortness of water the crown of the flue had been made red hot and forced downward to a great extent, without the plates being injured in any other way, hereby testifying both the strength of construction obtained by flanging the edges of the flue-joints, and also the unparalleled excellence of material.

The plates are rolled from **Fagersta (Sweden) Bessemer Ingots**. The flues of all the Marine Boilers from our establishment are, since many years, without exception, constructed of the same material.

GÖTEBORGS MEKANISKA VERKSTADS AKTIE-BOLAG.

Göteborg, Sweden.

ANNEX V.

9. **Gun Barrels.**

(See Annex No. 5.)

a. **A Series**, showing
the different stages in
the manufacture of
gun barrels, that are
rolled over balls from
punched pieces.

(See Annex No. 5.)

I, the undersigned, hereby certify, on requisition to that effect, that barrels manufactured at the Fagersta Steel Works have, for about the last three years, been exclusively employed for the small fire-arms constructed at the Swedish Government Gun Manufactory for the supply of the army; and that such barrels are still employed for the fire-arms now in course of construction at the said Manufactory.

Stockholm, the Tenth day of April, 1873.

(Signed)

C. G. BRITTHOLTZ,
Master of the Ordnance.
(“Påltygmästare.”)

Since the commencement of the year 1871, the Husqvarna Arms Manufactory has taken its requisite supply of Gun Barrels from the Fagersta Steel Works, and found the said barrels, both as regards material and make, to be of excellent quality.

On behalf of The Husqvarna Arms Manufactory Company
(Limited).

(Signed)

VICTOR ANKARCRONA,
Managing Director.

b. Gun barrel, that has been subjected to trials at the gun factory of Husqvarna, as described in the annexed statement.

(See Annex No. 6.)

ANNEX VI.

On the 27th of March, 1869, a steel gun barrel manufactured at the Fagersta Steel Works was subjected to testing experiments at the Husqvarna Gun Manufactory, in the presence of the undersigned; and during the progress of the experiments the following observations were noted:

1st proof: A charge of gunpowder $1\frac{1}{2}$ "lod" (5 drams, 1 scruple, 16 grains avoirdupois), 1 testing ball.

2d proof: A charge of gunpowder 3 "lod" (1 ounce, 3 drams, 12 grains), 2 testing balls.

3d proof: A charge of gunpowder 3 "lod" (1 ounce, 3 drams, 12 grains), 3 testing balls.

The above three proofs were discharged without any remarkable result.

4th proof: 3 "lod" (1 ounce, 3 drams, 12 grains), of gunpowder, 4 testing balls. Result: The powder-gas escaped through the touch-hole; the balls remained in the barrel, and had to be removed by smelting.

5th proof: $4\frac{1}{2}$ "lod" (2 ounces, 2 scruples, 8 grains), 4 testing balls. No effect on the barrel.

6th proof: $1\frac{1}{2}$ "lod" (5 drams, 1 scruple, 16 grains) of gunpowder. One ball was forced into a position of $7\frac{1}{2}$ "verkum" ($7\frac{1}{2}$ inches) from the muzzle. Result: A protuberance in the form of an egg was produced in the barrel, at the seat of the ball.

7th proof: 3 "lod" (1 ounce, 3 drams, 12 grains) of gunpowder. A ball was driven into a position of 1 "verkum" (1 inch) from the muzzle. Result: The same as in the previous proof, viz., The barrel was enlarged at the seat of the ball.

8th proof: 3 "lod" (1 ounce, 3 drams, 12 grains) of gunpowder. The ball at the muzzle. Result: The enlargement above described, produced by the seventh proof, was extended by the eighth proof almost to the muzzle.

Notwithstanding the barrel, after the discharge of each of the above proofs, was carefully examined, no other results could be discovered than those above described.

Lastly: it should be observed that the balls employed weighed originally 6.65 "ort" (7 drams, 2 scruples, 18 grains), but after they had been forced into their positions, and, consequently, part of their substance had fallen off, they only weighed 5.50 "ort" (6 drams, 1 scruple, 15 grains).

Husqvarna, dated as above.

(Signed)

B. MÜNCK,

Lieutenant-Colonel.

(Signed)

EMIL ANKARCRONA,

Managing Director of the Husqvarna Gun Manufactory.

(Signed)

C. E. NORSTRÖM,

Lieutenant-Colonel.

(Signed)

J. HOLMBERG,

Gun-smith.

(Signed)

A. J. GUSTAFSSON,

Inspector of Ordnance.

(Signed)

ANDERS HERRLIN,

Inspecting Officer.

ANNEX VII.

c. Five Gun barrels, subjected to severe testing experiments at Karl Gustaf's Stads Gun Manufactory, as described in the annexed statement.

(See Annex No. 7.)

d. **A Series**, showing the different stages in the manufacture of Gun barrels from hammered, solid pieces.

10. Tools for Rock Drilling.

Tool-Steel.

A Series of broken 1-inch square steel, showing the different fractures on account of different degrees of carbonization.

Steel Bars of various temper, welded together and broken, to show the fracture.

A Series of Bessemer products from the Bessemer converter taken out at

Report of the Proving Experiments, upon Barrels manufactured at the Fagersta Steel Works, made at the Karl Gustaf's Stad's Gun Manufactory, in the Month of May, 1872.

The Barrels were proved in the Proving House of the Manufactory with gunpowder from the Åker's Gunpowder Mills, of the make of 1865. The testing balls employed weighed 6 "ort" (7 drams, 11 grains avoidupois), and were 0.42 "decimal tum" ($\frac{5}{12}$ inch) in diameter.

First, three barrels, Nos. 1, 2, and 3, turned and bored as delivered from the steel works to the Gun Manufactory, were loaded and discharged.

In previous experiments with barrels from the Fagersta Steel Works, it had been found that no remarkable effect was produced until 1 ball and a charge of 9 "ort" (1 ounce, 2 drams, 2 scruples, 7 grains) were employed. The experiments, therefore, commenced—after the ordinary proof (a testing ball and a charge of 4.5 "ort" (5 drams, 1 scruple, 3 grains)—with the above mentioned ball and a charge of 9 "ort" (1 ounce, 2 drams, 2 scruples, 7 grains); after which the number of balls was increased to 9, with the same charge. The result was, that in two of the barrels the powder-gas did not force out the balls, but escaped through the touch-hole. These barrels were reloaded and discharged with the same result.

After the lead had been smelted away from the inside of these barrels, the experiments were continued with all three; the balls, however, being placed at the muzzles. This proof commenced with 1 ball and a charge of 0.5 "ort" (1 scruple, 16 grains), and ceased when the charge had been increased to 6 "ort" (7 drams, 11 grains), and the number of balls to 5.

In the following Minutes the results of the experiments are more fully stated.

Subsequently, 3 finished barrels, Nos. 1808, 2511, and 2635 were loaded and discharged.

Barrel No. 1808, after having been subjected to the ordinary proof, was discharged with the usual sharp cartridge, and a testing ball, placed 27 "tum" ($3\frac{1}{2}$ inches) from the chamber end of the barrel. The only result was, that a considerable protuberance was produced at the seat of the ball.

Barrel No. 2511 (rejected on account of defective make) was subjected to a similar proof, with the same result.

Barrel No. 2635 burst in the proof. In this experiment a testing ball was employed, and the charge was increased from 1 "ort" (1 dram, 12 grains) to 16 "ort" (2 ounces, 3 drams, 10 grains), when the barrel burst, after having borne 14 times the charge for which it was constructed.

Karl Gustaf's Stad, the 25th day of May, 1872.

(Signed)

E. G. TREFFENBERG,

Lieutenant in the Royal Göta Artillery,

Working-Officer at the Karl Gustaf's Stad Gun Manufactory,

ANNEX VII.—*Continued.*

Minutes taken, May, 1872, at the Proving of Gun Barrels
(Nos. 1, 2, and 3) manufactured at the Fagersta
Steel Works.

different periods during the "blow," with samples of slag, taken at the same time.

II. A **Collection of**

Steel samples from Fagersta, of various temper, tested at the Testing Works of Mr. D. Kirkaldy, in London. The whole forming a very complete series of experiments, made for investigating the strength of the material, by tension, elasticity, compression, and torsion, etc. A statement of the results is contained in **Special tables**, which may be obtained on application at the office of the Swedish Commission.

Number of Discharges.	Weight of the Charge in Swedish "ort" (1 ort = 1 dram 12 grains avoirdupois).		Number of Balls.	OBSERVATIONS.
	1 ort	1 dram 12 grains		
1	4.5		1	Barrels unaffected.
2	9		1	A slight enlargement was produced in all the barrels, at the seat of the ball.
3	9		2	The above-named enlargement was increased, and the calibre on each side of the seat of the ball was also somewhat increased; in addition to which, at the fourth discharge of Barrel No. 3, a protuberance was produced before the seat of the ball.
4	9		3	
5	9		4	
6	9		5	
7	9		6	
8	9		7	
9	9		8	
10	9		9	The powder-gas escaped through the touch-holes of barrels Nos. 1 and 2, without the balls being removed from their seats; while in Barrel No. 3 the balls were discharged.
11	9		9	Only Barrels Nos. 1 and 2 were loaded and discharged, with the same results as in the preceding proof.
WITH THE BALLS AT THE MUZZLES OF THE BARRELS.				
1	0.5		1	The powder-gas escaped through the touch-hole.
2	1		1	The balls were discharged; the barrels unaffected.
3	1		2	The balls were discharged; the barrels unaffected.
4	1		3	An enlargement was produced in the barrels at the seats of the balls.
5	1		4	The powder-gas escaped from the touch-hole of barrel No. 2.
6	2		4	The balls were discharged from barrel No. 2.
7	2		5	The powder-gas escaped from the touch-hole of barrel No. 2.
8	3		5	The powder-gas escaped from the touch-hole of barrel No. 1.
9	4		5	A protuberance was produced in barrel No. 3 at the seat of the ball.
10	5		5	A protuberance was produced in barrel No. 1 at the seat of the ball.
11	6		5	A protuberance was produced in barrel No. 2 at the seat of the ball.

Karl Gustaf's Stad, 25th May, 1872.

(Signed)

F. G. TREFFENBERG,

Lieutenant in the Royal Göta Artillery,

Working Officer at the Karl Gustaf's Stad's Gun Manufactory.

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